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Implementing a Strategy for Monitoring Inpatient Antimicrobial Use Among Hospitals in the United States

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Abstract

Measuring antimicrobial use is an important way to provide metrics that support more vigorous, facility-specific stewardship efforts, which in turn will be a major step toward reducing unnecessary use of broad-spectrum antimicrobials. Yet no single system is available in the United States that can meet stewardship needs at the level of individual hospitals and provide benchmarks, monitor trends, and measure the magnitude of antimicrobial use at the regional, state, and national levels. Therefore, the Centers for Disease Control and Prevention is pursuing 3 distinct and complimentary efforts that remain focused on providing “data for action,” including facility-level use metrics for benchmarking across comparable patient care settings, national estimates of usage patterns using sentinel surveillance sites, and limited assessments using proprietary data.

Keywords

antibiotic stewardship; patient safety; antibiotic resistance; antibiotic use; healthcare-associated infections; surveillance

Concern for the consequences of inappropriate and unnecessary antimicrobial use date to the late 1950s and early 1960s and has been codified under a variety of rubrics, culminating in the now widely accepted movement for antimicrobial stewardship. Adding to this growing sense of urgency for better stewardship is the rising threat of antimicrobial resistance [1]. Efforts to ensure appropriate antimicrobial use in hospitals and nursing homes have been critical to slowing the emergence of serious antimicrobial resistance threats, such as carbapenem-resistant Enterobacteriaceae [2]. Unfortunately, implementing effective stewardship activities in the inpatient setting can be problematic for a wide variety of reasons [3]. One major obstacle is a lack of tools to supply providers with accurate and reliable measures to reflect the quality of antimicrobial prescribing; facility-specific

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Notes

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antimicrobial use measures can inform interventions and monitor intervention effectiveness [4].

Currently, the US public health infrastructure lacks a systematic means for ongoing assessments of antimicrobial consumption in hospitals to either quantify national usage patterns, correlate usage patterns with resistance, or facilitate valid interfacility comparisons. Large-scale assessments of inpatient antimicrobial use have come from a variety of studies conducted in groups of acute care hospitals [4–6]. These reports, using standard pharmacy order or dispensing data across 30–130 hospitals, describe huge variations in usage patterns between facilities (interquartile range, 800–1000 defined daily doses [DDDs] per 1000 patient-days; range of 44%–74% of discharged patients having received any antimicrobial); these variations underscore the need for advancing the science of interfacility comparisons. This review describes the strategic approach to building a robust infrastructure for facility-level and national assessments of antimicrobial use measurement to promote best use of antimicrobials among hospitalized patients in the United States.

Starting in the late 1990s, the Centers for Disease Control and Prevention (CDC) supported national reporting of antimicrobial use through the Antimicrobial Use and Resistance (AUR) Module of the National Nosocomial Surveillance System, which was transitioned to the National Healthcare Safety Network (NHSN) in 2006. Initially, reporting into AUR for a cadre of facilities has identified a number of important challenges with collecting and analyzing antimicrobial use data [7]—most importantly that the implementation of manual aggregation of antimicrobial use data, usually done by hospital pharmacists, was too labor intensive to be sustained—and nearly all reporting to the AUR module stopped by 2006.

In an effort to improve antimicrobial use reporting by acute care hospitals in the United States, in July 2009 the CDC hosted a group of experts including infection preventionists, hospital pharmacists, hospitalists, infectious disease practitioners, public health partners, and antimicrobial stewardship practitioners to provide input on a federal program for conducting surveillance of antimicrobial use among inpatients at US hospitals. In these and other discussions, common themes emerged. First and foremost, practitioners wanted a system to monitor antimicrobial use that would help facilities assess the impact of their own stewardship efforts. Second was a desire for easily accessible comparative metrics (eg, facility benchmarking) on usage patterns. Many experts cited the example of healthcare-associated infections, where national, risk-adjusted benchmark infection rates have long been produced by the CDC and have been used by facilities to assess, compare, and improve their own infection rates. Third, use of DDDs per 1000 patient-days was not the ideal measure, especially as it is not applicable in pediatric settings. Fourth, antimicrobial use data needs to be reported electronically, given how labor intensive it would be to report manually. Fifth, a system to accomplish the objectives outlined above should ideally be accessible by any facility. In addition, there was recognition that a system should allow for national assessments to inform larger policy discussions and decisions about improving antimicrobial use. Such national assessments should include descriptions of which antimicrobials are most commonly used in US hospitals and make estimates on amount of usage as well as estimates on changes over time, and ideally how such estimates compare to other countries.

Recognizing that all of the immediate needs for measuring antimicrobial use could not be met by any single system or approach, the CDC is exploring 3 approaches to the monitoring and reporting of inpatient antimicrobial use in US hospitals: (1) ongoing sustainable facility-specific derived measures, (2) intermittently sampled evaluations from nationally representative hospitals, and (3) utilization of proprietary systems that track purchases of antimicrobials for specialized studies.

NHSN ANTIMICROBIAL USE AND RESISTANCE MODULE

Facility-derived measures should be the cornerstone of a national program, allowing hospitals to report, participate, and interpret their data to make quality improvement decisions at their local facility—that is, use the data to guide stewardship decisions. As such, the development of a revised Antimicrobial Use (AU) Option of the AUR Module has been a top priority for the CDC. Fortunately, the infrastructure of the CDC's NHSN provides an ideal platform for a national system to monitor facility-specific antimicrobial use. NHSN is now required for participation in the Center for Medicare and Medicaid Services (CMS) Inpatient Prospective Payment System, leading to use of the system already among roughly 6000 acute care hospitals. NHSN thus provides a well-established and recognized infrastructure for electronic, active, prospective surveillance of healthcare data from US hospitals. Second, using NHSN to monitor antimicrobial use would allow for benchmarking in that it is capable of providing results to facilities for comparison and quality improvement through existing software, security, and training. It is important to note that NHSN is already used for just this type of benchmarking for healthcare-associated infections. Third, there is the potential to link relevant outcomes related to antimicrobial use including measures of *Clostridium difficile* infection, susceptibility data among pathogens reported to be associated with HAIs, and eventually cumulative susceptibility data. Fourth, because participation in NHSN has begun to be required by CMS for healthcare settings other than acute care hospitals to participate in quality improvement programs, the opportunity exists to expand antimicrobial use measurement to settings such as outpatient dialysis facilities and long-term acute care hospitals in the future. Finally, NHSN is used by many state health departments to fulfill reporting requirements and work collaboratively with hospitals on preventing healthcare-associated infections. In a similar fashion, use of NHSN for antimicrobial use surveillance could enable regional collaborative stewardship efforts led by state health departments or their partners.

In the spring of 2012, NHSN was enabled to receive standard files for the AU option of the AUR module [8]. In its initial rollout, AU data will be summarized for the facility in location-specific measures of days of therapy per thousand days present. Existing data sources of the electronic medication administration records (eMARs) will be used to derive valid, comparable data from diverse proprietary pharmacy and administrative data systems designed to meet client hospitals' financial and regulatory demands, and reused for surveillance needs. Recent evidence suggests that days of therapy has advantages over DDD measures in acute care settings including limiting the impact of differences in formulary composition between hospitals on the overall metric and broader applicability among the pediatric population [4]. For the denominator, a more dynamic measure of "days present" was chosen over the more static "patient days," a decision informed by data showing that

patients sometimes receive doses of antimicrobials in multiple hospital locations on a given day. The “days present” denominator captures data from the hospital admission-discharge-transfer system and includes in the denominator a count for every location patients occupied for any time on a given day. The justification for utilizing “days present” over the more traditional “patient-days” includes allowance for all counts in the numerator (days of therapy, or DOT) to have been counted in the denominator, a situation that may not be true if only patient-days is counted in the denominator (eg, DOT given to patient X in both the medical intensive care unit and surgical intensive care unit [SICU] during the day, but patient-day was assigned to only SICU at midnight census). There is little experience with this denominator, and further evidence to justify this approach would be ideal. Although location-specific data may be presented in an unadjusted fashion, hospital-wide measures will utilize risk-adjustment methods that will need to be developed in the future.

POINT PREVALENCE SURVEY OF ANTIMICROBIAL USE IN THE UNITED STATES

The second approach to measuring inpatient antimicrobial use in US hospitals is aimed at providing national estimates of antimicrobial use through more detailed reporting from a national sample of hospitalized patients. Informed by discussions with the European Centre for Disease Prevention and Control (ECDC) and experience with the European Surveillance of Antimicrobial Consumption Network (ESAC-Net), the CDC has launched, in collaboration with 10 different states’ health departments, a national antimicrobial use and healthcare-associated infection point prevalence survey in a sample of hospitals within the CDC’s Emerging Infections Program. In 2011, a point prevalence survey was conducted using trained staff who reviewed medical records at participating hospitals. This approach relied on sampling inpatients at a few hundred hospitals; through statistical adjustments, national estimates were calculated. In addition to collecting information on the antimicrobial(s) patients were taking, abstractors also obtained information on the clinician-documented indication for the antimicrobial, allowing national estimates of inpatients of acute care hospitals receiving various agents by indication. Through repeat surveys every 2–3 years, trends in usage and characteristics of usage nationally will be possible.

Within this system, relevant clinical and laboratory data around the time the antimicrobials were given can also be abstracted. These data should allow some assessments of unnecessary or inappropriate use. Toward this end, a pilot evaluation is being conducted by trained staff in 2013 at program sites to review records of patients sampled in the 2011 point prevalence survey to identify potential areas for improving antimicrobial use. This assessment currently focuses on treatments for community-onset pneumonia, use of therapy for methicillin-resistant *Staphylococcus aureus* (MRSA), use of piperacillin/tazobactam, and treatments for urinary tract infections. Examples of proxy measures of inappropriate use include absence of vancomycin de-escalation for patients at low risk for MRSA infection, or treatment of asymptomatic bacteriuria. Such metrics, if validated as good proxy measures to identify areas requiring a more rigorous assessment of inappropriate use, could be used to approximate frequency of such use and inform stewardship activities and policies at the national level.

PURCHASE DATA ON ANTIMICROBIAL USE

CDC's third approach to monitoring antimicrobial use in US hospitals is the use of proprietary antimicrobial usage data collected by a variety of different organizations. These data may come from a variety of sources within hospitals; usually these include drug purchase information and/or claims and charge data, but may include pharmacy orders. The fact that these data are currently available and collected on an annual basis means that they can fill some immediate needs in the CDC's efforts to monitor antimicrobial use, including the magnitude of antimicrobial use among groups of hospitals and information on overall trends in use. There is quite a bit of experience using antimicrobial data collected from multiple hospitals in studies to describe the variations in antimicrobial prescribing in US hospitals as well as efforts to correlate prescribing patterns to prevalence of antimicrobial resistance [9–12]. These efforts include initial insights into methods for risk adjustments that will inform efforts to benchmark antimicrobial use data [4].

INFLUENTIAL EXPERIENCE

The European Union has made great strides in developing an ongoing system to evaluate regional differences in antimicrobial consumption. The ECDC collects data on antimicrobial consumption from 29 European Union and European Economic Area countries through the ESAC-Net, which is a Europe-wide network of national surveillance systems (data were collected by the ESAC project before it was transferred to ECDC in July 2011). Mostly populated by data related to purchase of antimicrobials [13, 14], this reporting has advanced from regular written reports to include an online interactive database [15]. This system serves the main purposes of ESAC-Net well: continuous surveillance of antimicrobial consumption in the European Union, evaluation of intercountry differences, feedback of data to participating member states, and provision of public access to information on antimicrobial consumption.

The European Union experience has greatly advanced the field of antimicrobial use measurement and has informed US efforts by highlighting how varied sources of antimicrobial use data may impact observed differences in measures obtained with these different sources [16, 17]. In addition, the reported measures have some inherent limitations, such as the poor applicability of DDDs in pediatric populations [5].

There are also a number of other lessons learned from published reports on antimicrobial use in US hospitals. These reports have relied on data from proprietary systems, including single-center studies or multicenter studies that are not nationally representative nor sufficiently large enough to allow projection to the national level [5, 6, 18, 19]. These reports, such as those from the European Union, highlight the importance of considering the source of data [16, 17]. Some have relied on pharmacy charges or purchase data, which may reflect at best patient charges that have not been well validated with respect to their correlation to actual antimicrobial consumption, or at worst wholesale distribution of antimicrobial sales data. The limitations related to poor validity of these data become more important when/if the data are used for patient-level, location-level, or even hospital-level evaluations; however, these limitations have a less pronounced impact on national summary

statistics. Other studies have used sources of data closer to actual consumption, such as pharmacy orders, although other reports suggest that even these data have limitations when compared to what patients actually receive [4, 6]. None of the current studies have used actual drug administration data, documented from patients' medication administration record, which is more reflective of patient receipt and accounts for transfers of patients between wards, changes in orders not reflective in a daily download of data, and returned doses not administered to the patient for numerous reasons.

IMPLEMENTATION CHALLENGES FOR CDC'S 3-PART STRATEGY

Clearly, the development of the NHSN Antimicrobial Use Option is complex and has required many detailed decisions to define an implementation strategy. Some of the most notable challenges and controversies addressed in such a strategy are outlined in Table 1.

Although only a small number of hospital pharmacy vendor systems that interact with eMAR systems have already configured their software to report to the AU module, over the next few years many facilities will find it easier to report these data through their hospital pharmacy systems. A significant barrier to enrollment remains the investments required by hospital staff to enable a system to begin monthly submission of data. Competition for such resources (health information technology, pharmacist) in US hospitals exists, and priority is generally given to projects tied to incentives or requirements. Fostering such reuse of data contained in the eMAR/BCMA systems calls for additional incentives and ongoing advocacy by organizational stakeholders at the local, state, and national levels and by hospital-based stewardship, pharmacy, infection control, and quality improvement staff.

Similar to the facility-specific NHSN AUR approach, there are logistical and operational obstacles to the success of the point prevalence survey. This second CDC strategy is resource intensive and requires extensive training of abstractors and significant data collection efforts, in addition to collaboration with almost 200 hospitals. Hence, any future prevalence surveys will depend on the availability of resources. The survey can capture the percentage of patients on antimicrobials on a given day, but aspects of indications and measures of appropriateness may include some inherent subjectivity as they are dependent on manual abstraction and at times interpretation of data. Fostering the required network of collaboration requires some stable infrastructure to ensure reliable assessments over time.

Challenges to the use of proprietary data for antimicrobial use surveillance, the third element of the CDC's strategy, include, first and foremost, that the data are proprietary, which means public health and academic partners have little influence over what data are collected. The proprietary nature of the data also limits access, even for facilities that may be contributing data to the system. The data collection was not designed to be representative of US hospitals; the data are usually collected retrospectively and sometimes with a considerable lag in reporting; hence, they are often not useful for monitoring the impact of stewardship interventions, even in facilities where the data are collected. In addition, links to patient information, when available, are usually tied to administrative data used for reimbursement (International Classification of Diseases, Ninth Revision codes) with inherent limitations for epidemiologic purposes.

CONCLUSIONS

Measuring antimicrobial use in such a way as to support facility-specific stewardship efforts will be a critical step toward making a large impact on reducing unnecessary use of broad-spectrum antimicrobials that is often associated with wasted resources, adverse events, and the emergence of antimicrobial resistance. It is clear that the variety of needs for measuring antimicrobial use in hospitals will require a hybrid approach. Hence, the CDC is pursuing 3 distinct and complementary efforts that remain focused on providing "data for action." Building a comprehensive approach to monitoring antimicrobial use among inpatients in US acute care hospitals will require the support of a broad array of partners, and the current and growing recognition of the urgent need for more antimicrobial stewardship will greatly facilitate engaging these myriad partners. The CDC hopes to provide leadership, both in developing and refining the methods for measuring antimicrobial use and in engaging partners in this critical effort.

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Table 1

Development of the National Healthcare Safety Network's Antimicrobial Use and Resistance Module: Implementation Strategy, Considerations, and Milestones

Controversy or Challenge	Implementation Decision	Considerations and Milestones
Source of data	Require electronically captured data from eMAR or BCMA systems	• These systems are capable of providing a single source of data most reflective of actual inpatient antimicrobial usage and minimize data collection burden. • Avoids limitations to antimicrobial purchase and dispensed data (lack of standardized systems). • Recognizes that some facilities would initially not be able to participate in the AU module as not every hospital currently has eMAR or BCMA [20, 21]. • These systems provide aspects of improved patient safety and prevent errors in dispensing drugs from the pharmacy [22] and at the bedside [23, 24]; eMAR/BCMA is rapidly becoming the standard in US hospitals. • 2008 survey among hospitals (Health Information and Management Systems Society): 69% had eMAR in operation [21], up from 46% in 2007 [20].
	Require electronically captured admission/transfer/ discharge data to populate number of patients present in each location at any time during each calendar day (days present)	• Includes allowance for all counts in the numerator (DOT) to have been counted in the denominator, a situation that may not be true if only patient-days is counted in the denominator. For example, a DOT given to a patient passing through both the MICU (and receiving antibiotics) and SICU (and receiving antibiotics) during the same day would be included in both MICU and SICU counts; patient-days assigned at midnight census would assign patient-day to only 1 location. • There is little experience with this denominator and further evidence to justify this approach would be ideal.
Degree of summarizing filtering of data	Days of therapy as a numerator for each hospital location separately, and overall for the entire hospital (includes emergency departments and observation units; excludes outpatient departments)	• Considering the complexity of assessing "appropriateness" and stakeholders' interest in tools for stewardship, reporting unit at location level allows for risk adjustment similar to methods used currently for healthcare-associated infection data. • Other summary measures (eg, length of therapy [patient-days receiving any antimicrobials], % of patients with changes in therapy after day 3 of hospitalization) could be added with future iterations of the protocol.
Hospital-level barriers to implementation	Fund 4 health departments in 2011–2012 to enlist early adopters of system Reliance on hospital and/or vendor IT support	• Through pilot program, 20 hospitals currently report monthly; additional voluntary initiatives anticipate roughly 50 facilities to be reporting by mid 2014.
	Only subset of pharmacy system or infection control system vendors will have/plan to configure system for reporting	• A limited number (approximately 4) of pharmacy system/ infection control vendors have taken the necessary steps to configure their systems to report to the AU Option. Vendor contacts at http://www.sidp.org/aurvendors.
	Investment of hospital informatics expertise to assure successful and complete access to eMAR data	• Validation of data feeds and file production are necessary; a systematic validation process in pilot hospitals and vendors identified common errors in data capture and reporting. • Initial validation of data requires roughly 20–40 personnel hours.

Controversy or Challenge	Implementation Decision	Considerations and Milestones
		• As requirements change over time and new antimicrobials are added, regular validation steps will be required, but will require less time.
Development of a quality measure	Plan to submit a quality measure in 2014 utilizing 2013 NHSN AU data to the NQF for consideration	• An NQF-endorsed measure would help facilitate the adoption of a quality measure on antimicrobial use. • Adding an NQF-endorsed antibiotic use measure to conditions of participation in the Center for Medicare and Medicaid Services' Inpatient Prospective Payment System will increase vendor participation/activity in this area.
Risk adjustment	Risk adjustment and benchmarking will initially parallel that used in healthcare-associated infections reporting (indirect standardization, use of observed/ expected ratios)	• With limited experience in this area [4–6], initial effort may be a transition to more sophisticated riskadjustment methods incorporating case-mix indices and/or regression modeling.

Abbreviations: AU, antimicrobial use; BCMA, barcode medical administration; DOT, days of therapy; eMAR, electronic medical administration record; IT, information technology; MICU, medical intensive care unit; NHSN, National Healthcare Safety Network; NQF, National Quality Forum; SICU, surgical intensive care unit.